

[10191/899]

METHOD FOR MANUFACTURING A SENSING ELEMENT

FIELD OF THE INVENTION

The ^{present} invention relates to a method for manufacturing a sensing element, in particular for determining the oxygen content in exhaust gases of internal combustion ^{engines.} ~~engines, having the features recited in the preamble of Claim 1~~

~~Background Information~~ BACKGROUND INFORMATION

^{sensing} The ~~sensing~~ elements are configured, for example, ^{as} ~~as~~ so-called planar sensing elements, which comprise a composite construction of individual layers arranged one above another in film form. The individual films of this composite construction are arranged one above another in defined fashion, resulting in various functional layers. The individual films of the composite construction are, for example, laid onto one another by means of a screen printing technique, as ~~so-called~~ green films. The sensing elements usually have solid electrolyte films, electrode films, heating, conductor films, insulation films, and protective films. ^{conventional} ~~known~~ sensing films ^{may} ~~can~~ also have substrate films with printed electrolyte layers, aluminum oxide substrate films with semiconductor sensors (TiO_2 , SrTiO_3). Instead of laying the green films onto one another, the latter ^{may} ~~can~~ also be obtained by individual printing steps. The arrangement of these

different films one above another results in a laminated composite construction from which the sensing element is obtained by sintering.

5 During testing of the sintered sensing element, or during utilization thereof as intended, the individual layers of the sensing element are exposed to different temperatures. Because of these sudden temperature changes which occur with differing intensity, the sensing elements experience a temperature shock
10 which leads to the occurrence of mechanical stresses in the surface region, in particular at the edges of the sensing element. In order to increase the temperature shock resistance of the sensing elements, ~~it is known, for example from U.S. Patent 5,144,249, to blunt the edges of the sensing element,~~
~~to equip~~ ^{equipping} them with a chamfer. Chamfering is accomplished by way of a grinding operation ~~after~~ sintering and after sectioning of the sensing elements. It is disadvantageous ~~in~~ ^{to subject} ~~this context that the already completed sensing elements are~~ ~~subjected~~ to a mechanical machining operation which is relatively complex and ~~can~~ ^{may} lead to undesired damage to the sensing elements.

SUMMARY OF THE INVENTION

~~Summary of the invention~~

25 The method according to the present invention ~~having the features recited in Claim 1~~ offers, in contrast, the advantage that blunting of the edges of the sensing element ~~can~~ ^{may} be accomplished in a simple manner without the risk of impairing the sensing element. ~~Because the~~ ^{The} edges of the sensing element

as a result,
are blunted prior to sintering, it is possible to blunt the
edge in any desired geometry using simple, non-chip-removing
methods. In particular, ~~a~~ blunting of the edges ~~can~~^{may} be
accomplished in a form deviating from a flat surface, for
example in a convex or concave form, so that mechanical
stresses which occur as a consequence of a temperature shock
to the blunted edges cannot result in the creation of cracks.

In a preferred embodiment of the present invention, provision
is made for the edges to be blunted by shaping, preferably by
stamping of the film composite construction present in the
green state. It is thereby possible, using a simple stamping
tool, to shape the edges of the composite construction of
green films in simple fashion, due to their soft consistency
prior to sintering. By configuring a corresponding stamping
tool, a blunting of the edges ~~can~~^{may} be executed in any desired
form. It is particularly advantageous if, ~~when~~^{once the} stamping tools
have ~~already~~ been used, the stamping films laid in place are
ones which allow shaping only of the edge region of the
sensing element, and leave the other regions, in particular
the planar regions of the sensing element, unmodified. In
order to prevent adhesion of the green film composite
construction of the sensing element in the stamping tool, the
stamping film ~~can very advantageously~~^{may be advantageously} be equipped with an
anti-adhesion coating, in particular Teflon.

In a preferred embodiment, ~~provision is moreover made for~~
blunting of the edges ~~to be~~^{is} accomplished by ~~way~~^{use} of a laser
~~treatment. This makes it possible, very advantageously, to~~

accomplish noncontact blunting of the edges of the sensing element in the green state, so that any mechanical loads on the green film composite construction ^{may} ~~can~~ be ruled out. ~~very~~
~~It is possible to advantageously~~
~~advantageously, it is possible to~~ adjust the contour of the
5 blunted edges of the sensing element by ^{using} ~~way of~~ a mask of an excimer laser that is preferably used.

By ^{using} ~~way of~~ the laser treatment, blunting of the edges ^{may} ~~can~~ preferably be accomplished even before sectioning of the green films present in the composite construction, so that blunting of the edges ^{may} ~~can~~ be accomplished very effectively. At the same time, the break points of the wafer ^{with} ~~having~~ the individual sensing elements ^{may} ~~can~~ thereby be defined.

15 It is also preferred, in particular, if the laser treatment simultaneously accomplishes blunting of the edges and sectioning of the green film composite construction. By adjusting the laser output and the geometry of the laser beam, it is thus possible to accomplish edge blunting and sectioning
20 in one operation.

~~Further advantageous embodiments of the invention are evident from the other features recited in the dependent claims.~~

25 ~~Brief Description of the Drawings~~

~~The present invention will be explained in more detail below in exemplary embodiments, with reference to the pertinent drawings in which:~~

Figure 1 shows a sectioned depiction through a sensing element;

Figure 2 shows a sectioned depiction through a panel of several sensing elements;

Figure 3 shows geometrical structures of lasers;

Figure 4 shows the use according to the present invention of a laser; and

Figures 5 and 6 show the use according to the present invention of a stamping technique.

~~Detailed Description~~

Figure 1 shows a sectioned depiction through a sensing element 10 which ^{may} ~~can~~ serve, for example, to determine an oxygen content in exhaust gases of internal combustion engines in motor vehicles or of furnaces. Since the configuration and function of a sensing element 10 of this kind are commonly known, only the configuration that is important for explaining the ^{present} invention will be described below. The sensing element substantially has an elongated, flat-plate configuration that is composed of individual strata of various functional layers. As ~~the sectioned depiction shown in~~ Figure 1 illustrates, sensing element 10 possesses an electrochemical measurement cell 12 and a heating element 14. Measurement cell 12 includes a first solid electrolyte film 16 and a second solid

electrolyte film 18 which has an integrated reference gas conduit 20. A measurement electrode 22 is associated with a measured-gas-side surface of electrolyte film 16, and a reference electrode 24 is associated with the surface associated with reference gas conduit 20. A porous cover layer 26 is arranged above measurement electrode 22.

Heating element 14 has heating conductors 32 embedded in insulation layers 28 and 30. Adjacent to insulation layer 30 is a further cover layer 34.

Solid electrolyte films 16 and 18 and cover layer 34 are made, for example, of a stabilized zirconium oxide (ZrO_2). Electrodes 22 and 24 and heating conductors 32 are made, for example, of a platinum cermet. Insulation layers 28 and 30 are made, for example, of a mixture of aluminum oxide (Al_2O_3) and glass-forming components.

The entire composite construction of individual layers possesses, when viewed in cross section, an approximately parallelepipedal configuration, at least edges 36 running in the longitudinal direction of the sensing element, ~~having~~ ^{have} a chamfer 38.

Sensing element 10 is manufactured by successive lamination of the individual layers onto cover layer 34, which at the same time constitutes a support. Definition of the layers ~~can~~ ^{may} be accomplished by screen printing of a paste material which has the respective composition of the layer. After completion of

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this lamination, there results a composite construction of
so-called green films of the individual layers, which possess
a relatively soft consistency. The composite construction is
then subjected in ^{a conventional manner} ~~known fashion~~ to a sintering operation,
sensing element 10 ^{is} ~~being~~ created under the action of
temperature and ^{optional} ~~optionally~~ pressure.

According to the present invention, provision is now made,
before sintering, for patterning chamfers 38 of edges 36.
10 Individual possibilities for achieving chamfers 38 will be
discussed below.

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Figure 2 shows a portion of a ~~so-called~~ panel of a plurality
of sensing elements 10 present in the green state. In this,
the individual layers of sensing elements 10 are laminated
simultaneously for a plurality of sensing elements 10, and the
composite construction of green films for one sensing element
10 is then sectioned out. Figure 2 shows portions of three
sensing elements 10. Parts identical to those in Figure 1 are
given identical reference characters, and will not be
explained again. ~~detailed depiction being dispensed with here~~
~~for reasons of clarity.~~ After lamination, cutting lines 40 are
defined at which sectioning of sensing elements 10 is
accomplished. Prior to sectioning of sensing elements 10, a
defined surface depression 42 ^{may} ~~can~~ be introduced at cutting
lines 40. This surface depression 42 ^{may} ~~can~~ be executed, for
example, using an excimer laser 44 which has a specific mask.
Figure 3 shows, for example, two possible masks. According to
the left-hand depiction, excimer laser 44 ^{may} ~~can~~ possess a

triangular mask so that surface depressions 42 are triangular in accordance with this depression. According to the exemplary embodiment depicted on the right in Figure 3, the mask ^{may} ~~can~~ also have delimiting surfaces extending in concave fashion.

^{Other} ~~Also conceivable are other~~ exemplary embodiments which exhibit mixed forms of planes running at various angles and/or concave and/or convex delimiting surfaces. ^{are also possible} ~~are~~

As Figure 4 illustrates, excimer laser 44 is moved along the surface of the composite construction of green films. For this purpose, either excimer laser 44 ^{may} ~~can~~ be movable, and/or the green films ^{may} ~~can~~ be moved past excimer laser 44. Surface depression 42 is patterned in terms of its depth and feed rate in accordance with the output setting of excimer laser 44.

The patterning of surface depressions 42 yields blunted edges 36 with their chamfers 38. Sensing elements 10 are then sectioned along cutting lines 40, and are then subjected to the sintering operation. Sensing element 10 shown in cross section in Figure 1 is then created. Because chamfers 38 are patterned while the films of sensing element 10 are in the green state, and because of the noncontact patterning with excimer laser 44, sensing element 10 is not subjected to any mechanical stress, thus substantially ruling out damage.

Sectioning of the sensing elements ^{may} ~~can~~ be accomplished via a further treatment with an excimer laser which has a corresponding mask. It is also possible, however, by selecting a mask and an output level for excimer laser 44, to execute

the surface depression and sectioning in one operation.

Figure 5 indicates a further possibility for patterning .
chamfers 38. In this, a sensing element 10 is acted upon by a
5 stamping apparatus 45 after sectioning of the composite
construction of green films. Stamping apparatus 45 possesses a
contour 46 which allows shaping of edges 36 in such a way that
the ~~latter~~ ^{edges 36} then exhibit chamfers 38. Depending on the shaping
of contour 46, chamfer 38 ~~can~~ ^{may} also have a different contour as
10 a result of stamping, for example planar and/or convex and/or
concave sections. Contour 46 of stamping apparatus 45 ~~can~~ ^{may} be
created either by manufacturing a corresponding stamping
apparatus 45, or by laying a stamping film 48 into stamping
apparatus 45. Stamping film 48 is preferably equipped with an
15 anti-adhesion coating, for example Teflon or titanium nitride.
Since the green films still have a relatively soft consistency
in the case of this shaping as well, chamfers 38 ~~can~~ ^{may} easily be
stamped in without causing impairment to the prefabricated
sensing element 10.

Figure 6 shows a further exemplary embodiment in which
stamping of a composite construction of sensing elements 10
~~can~~ ^{may} be accomplished. For this, stamping apparatus 45 possesses
a stamping contour 50 which exhibits projections 52
25 corresponding to depressions 42. Stamping contour 50 ~~can~~ ^{may} also
be equipped with an anti-adhesion coating. With the exemplary
embodiment shown in Figure 6, it is easy to stamp a plurality
of sensing elements 10 in a multiple panel with one stamping
step, subsequent sectioning occurring along cutting lines 40.

Stamping apparatus 45 ^{may} ~~can very~~ advantageously have an upper die 54 and a lower die 56, so that the upper and lower sides of sensing elements 10 ^{may} ~~can~~ be stamped simultaneously in one process step. Because of the relatively soft consistency of the as-yet unsintered sensing elements 10, surface depressions 42 ^{may} ~~can~~ be stamped in with little energy expenditure, so that damage to the structure of sensing elements 10 ^{may} ~~can~~ be excluded.

It is self-evident that when chamfers 38 are patterned either using excimer laser 44 or with stamping apparatus 45, both sides of sensing element 10 are processed. For this purpose, either an apparatus acting in double-sided fashion ^{may} ~~can~~ be provided, or the green film composite construction of sensing elements 10 is turned over.

In ^{sum} ~~all~~, it is clear that the configuration of chamfers 38 in various contours, which is desirable in order to increase the temperature shock resistance of sensing element 10, ^{may} ~~can~~ be effected using easily implemented actions. The outlay for tooling is relatively low, and the latter is subject essentially to no wear, so that long service lives may be expected. The additional use of consumable materials, for example as in the case of grinding of the sintered sensing element 10 defined in the existing art, is entirely eliminated.